Paediatric robotic surgery and urology: where are we?

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Introduction

The uptake of robotic surgery by paediatric surgeons has been slower compared to our adult counterparts (Fig. 1). 3 mm minimally invasive neonatal surgery is challenging with the current robotic platforms and few neonatal cases have been reported [1–3]. The improved dexterity and lower complication rate afforded by robotic assisted surgery is the gold standard for adult procedures such as prostatectomy [4] and increasingly colorectal surgery [5]. In paediatrics, reconstructive procedures that involve prolonged and advanced suturing skills, such as pyeloplasty and fundoplication, were expected to be most applicable.

This article aims to provide an overview of the current updated levels of evidence for some of the main procedures undertaken by paediatric surgeons and urologists using robotic technology.

Pyeloplasty

The first robotic pyeloplasty was described in 2006 [6]. A decade later Cundy et al. [7], demonstrated through a meta-analysis similar outcome results when comparing robotic to the open approach though no level 1 evidence data were evident. The main difference between the two approaches was operative time and cost, with robotic significantly slower and more expensive. Other multi-centre studies since then have shown some reduction in hospital stay [8, 9] but a multi-centre prospective RCT trial would be needed to accurately compare the laparoscopic and the robotic approach.

The power of such a study would require a large number of patients, as outcome differences between both modalities is likely to be small.

Ureteral re-implantation and ureteroureterostomy have been shown to be comparable in a few small series [10–14].

Vesico-ureteric reimplantation (VUR)

Fewer studies exist in this field. Kasturi et al. demonstrated excellent outcomes for vesico-ureteric reflux using a robotic assisted approach [15]. Smith et al. compared outcomes of resolution of VUR with the open approach. They found no significant differences when using the robot though complications such as bladder and ureteral leak did seem to be more frequent [16]. The open group demonstrated a higher rate of post-operative bladder spasm and therefore the overall frequency of complications was described as equivocal. Both reports discuss a shorter length of stay when compared to the open approach.

Nephrectomy and hemi-nephrectomy

The adult literature produced a meta-analysis describing favourable results with robotic nephrectomy compared to laparoscopic [17]. A lower conversion rate to radical nephrectomy, renal function using indexed estimated glomerular filtration rate, a shorter length of hospital stay, and a shorter warm ischemia time, all were improved with robotic procedures. In 2015 Till et al., also published a meta-analysis examining eleven paediatric studies that reported on the differences between conventional laparoscopy compared to laparoscopic single site and robotic surgery, in relation to partial and total nephrectomy [18]. The paediatric data did not offer any clear advantages over conventional laparoscopy and the operative time and cost was significantly increased.

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Fig. 1 View of the console for robotic procedures

There were, however, far few patients in the paediatric data studies.

Anti-reflux surgery

Laparoscopic anti-reflux surgery in children has very favorable outcomes in children when compared to the open approach [19].

The majority of publications involve the fundoplication. The demand on the surgeon for this procedure in terms of suturing is considerably less than that of a reconstructive urological procedure though awkward angles and hiatal hernia reconstruction can be more involved, hence the robotic approach could offer advantages (Figs. 2, 3). Darzi's group in 2015 published a meta-analysis [20] which did not demonstrate any significant differences though a need for dilatation following a presumed tight wrap, was more frequent in the laparoscopic and robotic procedures. There were no level-1 evidence studies.

A similar group in Leeds also reviewed a prospective database to examine the learning curve for robot-assisted fundoplication [21]. Statistically significant transitions beyond the learning phase were observed at cases 42, 34, and 37 for docking, console and total operating room times, respectively. A steep early learning phase for docking time was overcome after 12 cases.

Cholecystectomy and splenectomy

No published studies to date have demonstrated a significant benefit to the paediatric patient when comparing robotic with laparoscopic. Unlike fundoplication, no direct comparisons

Fig. 2 Operation room view and team setup for robotic procedures

Fig. 3 View of the robotic arms during a laparoscopic fundoplication

have been made and recent data so far consist mostly of case series [15, 22]. The main advantage that these cases seem to offer is that of useful training experience for robotic skills.

Hepaticoenterostomy

Roux-en-Y hepaticoenterostomy for choledochal cyst excision involves delicate portal dissection and a sutured anastomosis. Robotics again would seem to offer the paediatric hepatobiliary surgeon significant advantages though to date there are few case reports [23, 24].

Case reports and small series have been published that describe a range of other general paediatric surgery procedures such as diaphragmatic hernia repair [2, 25], Heller's cardiomyotomy for achalasia [26, 27], duodenojejunostomy for SMA syndrome [28], duodenal atresia repair [3], and anorectal pull-through for anorectal malformations [15]. Currently these case studies are mostly demonstrating feasibility rather than equivalence/superior outcomes.

Cost effectiveness of robotic surgery

The cost of a setting up a robotic surgical program is significant. Even once established, the ongoing costs can be prohibitive to many paediatric units. Various publications examine the different procedures when compared to standard laparoscopy. A group from Indiana examined open and robotic pyeloplasty over a 9-year period in 18 American children's hospital [29]. They found an increased cost per case by nearly \$4000 for robotic surgery. The length of stay was shorter, but this still did not offset the significant procedural cost difference. The increased charges were cited as mainly operating theatre and anaesthetic charges. As patents expire and an increasing competitive market grows, outlay costs will no doubt reduce.

Conclusions

Robotic procedures in paediatric surgery are increasingly reported. The Patient Health Information System in the US reports an increase of 19.8% year on year since 2008 [29]. Financial restrictions in many European public health markets will likely demonstrate a reduced growth when compared to the US. Over the next decade, the introduction of new, more affordable robotic platforms is likely to alter this.

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